REMARKS

Claim 1 has been amended to incorporate the subject matter of claim 8. Claims 2-6 and 9-15 have been amended to improve antecedent basis and to more positively recite method limitations. No new matter has been added.

The Office Action mailed April 18, 2005, has been received and reviewed. Claims 1-15 are currently pending in the application. Claims 1-15 stand rejected. Applicant has amended claims 1-6 and 9-15, canceled claims 7 and 8, and respectfully requests reconsideration of the application as amended herein.

35 U.S.C. § 103(a) Obviousness Rejections

Obviousness Rejection Based on U.S. Patent No. 5,847,461 to Xu *et al.* in View of U.S. Patent No. 6,217,721 to Xu *et al.*

Claims 1, 3-5, and 7-11 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 5,847,461 to Xu *et al.* ("Xu '461") in view of U.S. Patent No. 6,217,721 to Xu *et al.* ("Xu '721"). Applicant respectfully traverses this rejection, as hereinafter set forth.

M.P.E.P. 706.02(j) sets forth the standard for an obviousness rejection:

> To establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and not based on applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991).

The obviousness rejection of claims 1, 3-5, and 7-11 is improper because the cited references do not teach or suggest all of the claim limitations. In addition, the cited references do not provide a motivation to combine to produce the claimed invention.

Xu '461 teaches a process of filling contact openings and vias in an insulating layer of an integrated circuit structure. Xu '461 at column 1, lines 16-19. The same metal is used to fill the contact openings and vias and to form electrically conductive interconnect or wiring harness. *Id.*

at column 2, lines 19-27. The integrated circuit structure includes openings in the insulating layer. *Id.* at column 3, lines 13-18. A barrier layer is formed over the insulating layer and sidewalls of the openings. *Id.* at column 3, lines 18-22. The barrier layer is formed from titanium nitride. *Id.* at column 4, lines 3-8. A patternable metal layer is then deposited into the openings. *Id.* at column 4, lines 17-23. The patternable metal layer covers the openings or extends slightly downward into the openings. A cap layer is then formed over the patternable metal layer. *Id.* at column 6, lines 26-27. The cap layer is formed from carbon, silicon oxide, titanium, tungsten, or tantalum. *Id.* at column 6, lines 59-62. The patternable metal layer is then extruded into the openings by heating the integrated circuit structure so that plastic deformation of the patternable metal layer occurs. *Id.* at column 6, line 66 through column 7, line 4. As such, the patternable metal layer completely fills the openings. *Id.* at column 7, lines 46-62.

Xu '721 teaches an aluminum sputtering process that is used to fill vias or contacts. Xu '721 at Abstract. The vias or contacts are first precoated with a liner layer. *Id.* at column 9, lines 23-25. The liner layer includes three sublayers: a first sublayer of titanium, a second sublayer of a titanium compound, and a third sublayer that is graded from titanium nitride to pure titanium. *Id.* at column 12, line 50 to column 13, line 2. The third sublayer is represented as a TiN_x layer, where x is the atomic percentage of nitrogen and varies from 0 to 1. *Id.* at column 13, lines 1-6. The second sublayer, which a titanium nitride sublayer, is formed by sputtering titanium from a titanium target and reacting the titanium with nitrogen gas. *Id.* at column 12, lines 61-67. A metal layer is then deposited over the liner layer. *Id.* at column 14, lines 15-20.

The cited references do not teach or suggest all of the limitations of claim 1 because they do not teach or suggest "forming a seed layer on the diffusion barrier layer . . . wherein the material comprising the seed layer consists of aluminum, titanium nitride, titanium, or titanium aluminide. As acknowledged by the Examiner, Xu '461 does not teach or suggest forming a seed layer. Office Action of April 18, 2005, p.3. Applicant respectfully submits that Xu '721 also does not teach or suggest this limitation. While the Examiner argues that layer 164 of Xu '721 is analogous to the recited seed layer, Xu '721 does not teach or suggest that layer 164 consists of aluminum, titanium nitride, titanium, or titanium aluminide. Rather, layer 164 is a graded TiN_x layer having TiN in one portion of the layer and pure Ti in the other portion of the layer. As such, layer 164 does not consist of aluminum, titanium nitride, titanium, or titanium aluminide.

The cited references also do not teach or suggest the limitation of "removing portions of the energy absorbing layer and the electrically conductive layer that are situated above the top surface of the dielectric material." Nothing in Xu '461 teaches or suggests this limitation because, as shown in FIG. 4, the metal layer and the cap layer remain on the integrated circuit structure. As described in Xu '461, the same metal is used as the filler in the openings and as the electrically conductive interconnect or wiring harness. Therefore, if portions of the metal layer above the top surface of the dielectric material were removed, as asserted by the Examiner, the resulting structure in Xu '461 would not have the same metal functioning as the filler in the openings and forming the electrically conductive interconnect or wiring harness. Xu '721 also does not teach or suggest removing portions of the energy absorbing layer and the electrically conductive layer that are situated above the top surface of the dielectric material.

The cited references also do not provide a motivation to combine to produce the claimed invention. To provide a motivation or suggestion to combine, the prior art or the knowledge of a person of ordinary skill in the art must "suggest the desirability of the combination" or provide "an objective reason to combine the teachings of the references." M.P.E.P. § 2143.01. The mere fact that references can be combined or modified does not render the resultant combination obvious unless the prior art also suggests the desirability of the combination. *Id.* (emphasis in original).

As acknowledged by the Examiner, Xu '461 does not teach or suggest the limitations of "forming a seed layer on the diffusion barrier layer over the top surface of the dielectric material and within the recess, the diffusion barrier layer comprising a material having a melting point greater than or equal to that of a material comprising the seed layer, wherein the material comprising the seed layer consists of aluminum, titanium nitride, titanium, or titanium aluminide" and "forming an electrically conductive layer on the seed layer over the top surface of the dielectric material and within the recess, the material comprising the diffusion barrier layer having a melting point greater than that of a material comprising the electrically conductive layer, the material comprising the seed layer having a melting point greater than or equal to that of the material comprising the electrically conductive layer." Therefore, the Examiner relies on Xu '721 as teaching these limitations.

However, Applicant respectfully submits that nothing in the cited references, when combined, suggests the desirability of the combination, or provides an objective reason to combine the teachings of the references. Specifically, nothing in Xu '461 suggests forming a seed layer, let alone forming a seed layer that consists of aluminum, titanium nitride, titanium, or titanium aluminide. Furthermore, the barrier layer in Xu '461 is formed on the insulating layer and the metal layer 30 is formed on the barrier layer. Therefore, Xu '461 does not teach or suggest forming a seed layer on the diffusion barrier layer. Xu '721 also does not teach or suggest forming a seed layer on the diffusion barrier layer. Rather, the TiN_x layer 164 is formed on the second sublayer of the titanium compound, which is itself formed on the first sublayer of titanium.

The Examiner states that "it would have been obvious to one of ordinary skill in the art at the time of the invention was made to form a seed layer after the formation of the barrier layer and prior to the formation of the conductive layer, and having the thermal properties as taught by Xu '172 in the interconnect method of Xu '461, since heating the barrier layer in a nitrogen environment substantially reduces the electronic barrier at the metal-semiconductor interface . . . and the addition of titanium nitride as a seed layer improves the flow of aluminum into an interconnect at moderate temperatures." Office Action of April 18, 2005, p. 4. However, even assuming *arguendo* that the Examiner's motivation is true, the claimed invention still would not be produced by the combination because the above-mentioned limitations would not be taught or suggested. Specifically, any resulting seed layer would not consist of aluminum, titanium nitride, titanium, or titanium aluminide and would not be formed on the diffusion barrier layer over the top surface of the dielectric material and within the recess.

Since the cited references do not teach or suggest all of the claim limitations and do not provide a motivation to combine to produce the claimed invention, the obviousness rejection of claim 1 is improper and should be withdrawn.

Dependent claims 3-5 and 7-11 are allowable, *inter alia*, as depending from an allowable base claim.

Claim 5 is further allowable because the cited references do not teach or suggest heating the diffusion barrier layer in an environment substantially containing a nitrogen gas prior to forming a seed layer on the diffusion barrier layer. The Examiner states the Xu '721 teaches this

limitation. However, contrary to the Examiner's assertion, Xu '721 only teaches that the second sublayer is formed by sputtering titanium from a titanium target and reacting the titanium with nitrogen gas.

Obviousness Rejection Based on Xu '461 in View of Xu '721 and further in view of U.S. Patent No. 5,869,395 to Yim

Claims 2, 6, and 12-15 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Xu '461 in view of Xu '721, and further in view of U.S. Patent No. 5,869,395 to Yim ("Yim"). Applicant respectfully traverses this rejection, as hereinafter set forth.

The teachings of Xu '461 and Xu '721 are as previously described.

Yim teaches a simplified hole interconnect process. Yim at the Abstract. At least one interconnect layer is located on a contact or via layer of a semiconductor wafer. *Id.* at column 2, lines 21-23. The via layer includes a plurality of patterned openings that are in substantial alignment without offset from each other. *Id.* at column 2, lines 23-28.

Claims 2, 6, and 12-15 depend from claim 1 and, therefore, include all of the limitations of claim 1. As such, claims 2, 6, and 12-15 are allowable, *inter alia*, as depending from an allowable base claim.

In addition, Yim does not cure the above-mentioned deficiencies in Xu '461 and Xu '721 and, therefore, does not teach or suggest all of the claim limitations and does not provide a motivation to combine to produce the claimed invention.

ENTRY OF AMENDMENTS

The amendments to claims 1-6 and 9-15 should be entered by the Examiner because the amendments are supported by the as-filed specification and drawings and do not add new matter to the application.

CONCLUSION

Claims 1-6 and 9-15 are believed to be in condition for allowance and an early notice thereof is respectfully solicited. Should the Examiner determine that additional issues remain that might be resolved by a telephone conference, he is respectfully invited to contact Applicant's undersigned attorney.

Respectfully submitted,

Joseph A. Walkowski
Registration No. 28,765
Attorney for Applicant
TRASKBRITT
P.O. Box 2550
Salt Lake City, Utah 84110-2550
Telephone: 801-532-1922

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